The Bean Lab

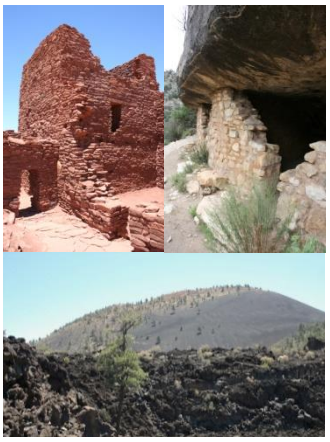
An exploration of the Flagstaff Area National Monuments, through an agricultural experiment.

Walnut Canyon, Sunset Crater Volcano, and Wupatki National Monuments

Grades 2-5

Created by:
Amanda Stalvey
Teacher-Ranger-Teacher
July 2013

Overview of Lesson:



This lesson is designed to help teachers bring a little part of the National Park Service and its unique monuments into the classroom, and hopefully inspire young students, their classes, and families to come and visit these parks. After completing this lesson, teachers have the opportunity and are encouraged to plan a field trip to one of the National Monuments highlighted here.

The purpose of this lesson is to provide a hands-on inquiry lesson focused on comparing how native food plants grow at three culturally historic places near Flagstaff, Arizona. Students will plant and grow Hopi Black Beans in three different soil types taken from areas *near* Walnut Canyon National Monument, Wupatki National Monument, and Sunset Crater Volcano National Monument. Students will take qualitative and quantitative data on the growth rates and productivity of each soil sample, and compare that to the history of farming in each monument, and the cultures that lived there. This lesson is designed to be a multi-week lesson, with only a small portion of each day actually dedicated to taking data. There are three major learning events within this lesson: 1) The background and setup of the lab; 2) The collection of data and observations; 3) A discussion and reflection on the results.

This lesson should be used as a map to guide instruction; it is up to each individual teacher to dictate how deep the lesson may go. If the lesson is followed exactly, it will provide a great overview of farming, soil comparisons, and cultural understanding, with plenty of room for the teacher to delve deeper into each subject and extend the learning opportunities.

Duration: **~ 3 Weeks**

It is suggested that you plan at least **three weeks** for measurable rate of growth to occur. There are many opportunities for extension, and the lesson may be extended depending on what your desired outcome is. Growth rates may be affected by available sunlight, water pH, and humidity.

Learning Objectives:

Guiding Question: How does the soil type at Walnut Canyon, Wupatki, and Sunset Crater Volcano National Monuments affect the growth rate of the Hopi Black Bean?

Critical Content: Learn how the three geologically different areas affected farming by the Ancestral Puebloans.

Student Objectives: Students will …

- develop an experimental hypothesis based on observations and background information
- carry out an inquiry experiment, and collect qualitative and quantitative data
- reflect on their predictions compared to experimental outcome
- reflect on the impacts that abiotic factors (soil type) has on the growth rate of native plants

Standards:

Common Core ELA Standards:

- SL.2-5.2
- W.2-5.7

Arizona State Standards:

Social Studies:

- Cross Grade Standards 2-5
  - S1C1: Research Skills for History
  - S1C2: Early Civilizations
  - S4C2: Places and Regions
  - S4C5: Environment and Society
- Grade 2:
  - S1C1 PO3; S2C1 PO3
- Grade 3:
  - S1C1 PO2; S2S1C1 PO2
- Grade 4:
  - S1C1 PO4; S1C1 PO3; S1C2 PO1b; S1C2 PO2; S2C1PO4
- Grade 5:
  - S1C1 PO5; S1C1 PO4; S2C1 PO5

Science:

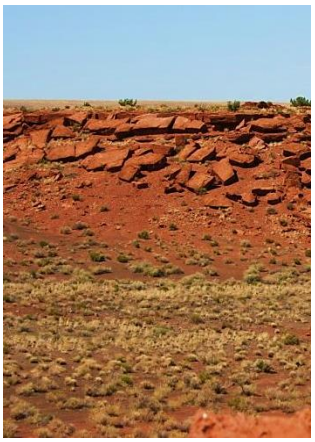
- Cross Grade Standards 2-5
  - S1C1: Observations, Questions, and Hypothesis
  - S1C2: Scientific Testing
  - S1C3: Analysis and Conclusions
  - S1C4: Communicate results of investigation
  - S3C1: Changes in Environments
- Grade 2:
  - S3C2 PO1
- Grade 3:
  - S1C4 PO3; S3C2 PO1; S4C1; S4C3 PO1; S4C3 PO5; S6C1 PO6
- Grade 4:
  - S4C3 PO4

The Soils:

In accordance with Federal Law, it is illegal to take any resources from National Park Service land. As such, the soils contained in this lesson are representative of the soils found at each monument and were procured from Forest Service Land just outside each monument boundary with the permission of the Coconino National Forest Service. The soils for this project were taken from areas that the Forest Service Soils Specialist recommended as being representative of the soils used for farming at each monument. We would like to thank the National Forest Service for their information and help in creating this project.

The representative Walnut Canyon soil is lighter in color, and is derived from Kaibab Limestone.

The Sunset Crater Volcano soil is a coarser black soil that is indicative of eroded cinders from the cinder volcano's eruption.



The Wupatki soil is redder in nature from the sedimentary Moenkopi Formation in the area.

Schools Residing in Arizona:

We are able to provide the list of materials from the "Classroom Materials Kit" to you at your classroom via mail or if you reside near Flagstaff Area National Monuments headquarters office you are welcome to come pick it up in person. Please contact Holly Richards at Wupatki National Monument (928) 679-2365, or by email at Holly_Richards@nps.gov to make arrangements.

Schools Outside Arizona:

Unfortunately, due to Department of Agriculture restrictions in each state, we are unable to mail any organic lab materials outside the state of Arizona. We are happy to send the rest of the kit to your classroom, and provide directions for adapting this lesson to fit your class and area. The Hopi Black Beans may be purchased commercially; however, obtaining the soil for your area may require a little more creativity.

Suggested Modification It is suggested to contact one of the commercial soil distributors or quarries in your state, and find out if they carry any soils similar to our three monuments in Arizona.

Walnut Canyon soil is Limestone derived, Wupatki is derived from eroded Moenkopi Formation (in a pinch you could use a soil derived from red sandstone), and Sunset Crater's soil is actually small sized black cinders ~ 6mm or less, the smaller the better.

You may also consider looking at the soils around the National Monuments in your area and contacting the appropriate Land Management Agency that controls the lands surrounding those monuments in order to obtain permission to collect the soils and adapt this lesson to fit your own local parks. Or just look at three geologically different soil compositions from around your area and compare them that way. There is a lot of room for adaption with this lesson and could go in many different directions.

Materials:

Classroom Materials Kit: (Set for 35 students)

~ 35 (5oz) clear plastic cups (1 per student)
~ 10 plastic spoons (approx. 5 mL each)
~ 70 Hopi Black Beans (2 beans per cup)
~ Approximately 4 cups or 946 grams Walnut Soil
~ Approximately 4 cups or 946 grams Wupatki Soil
~ Approximately 4 cups or 946 grams Sunset Soil

Teacher Provided:

~ Needle or pin to puncture the bottom of each cup (3 holes in the center of the cups)
~ Sunlight/Solar Plant Lab with UV lights?
~ Water
~ Rulers
~ Marker or Sharpie for labeling
~ Trays for placing cups and water drainage

Before Getting Started:

~ Double check that you have all materials.
~ Photo copy the background information, and support materials.
~ Photo copy and make Lab Data Journals for each student.
* It is suggested that you use colored construction paper as a cover for the journal, but it is not a requirement.

Background Information:

Please see the handouts in the appendix. It is up to the teacher how much background information to provide to the students. It is suggested for older students who have computer access to use the National Park Service webpages specific to each monument to gain more information. The main webpage is www.nps.gov Walnut Canyon: www.nps.gov/waca
Sunset Crater Volcano: www.nps.gov/sucr Wupatki: www.nps.gov/wupa

Procedure:

Step 1: **Background information**. As a class, read about the Ancestral Puebloans who lived near or around Sunset Crater Volcano, Wupatki, and Walnut Canyon (see appendix). As a class discuss what plants need to grow and what was grown.

Step 2: Divide the class into three equal groups, one for each monument. Have each group observe what they notice about the soil from around their monument, and draw or record what they see in their Lab Journals. Have them touch; smell and look at their soil, then, as a group, describe their soil to the whole class. (Refer to "The Soils" section from the lesson description and Background sheets for more information about how and where the soils were taken.)

Step 3: **Hypothesis**. Have the students hypothesize (individually or as a group) which soil is going to grow the tallest beans in the shortest amount of time, and describe why. This should be recorded in their Lab Data Journal on the first page.

Step 4: **Set up**. It is suggested that the teacher moistens the soil the night before the lab to help the soil absorb the water for the students (possible hydrophobic reaction).

I. Each student will be responsible for growing their own bean plant. Pass out the cups to each student and have them label their cup with their name and soil type. There will need to be 3 tiny drainage holes at the bottom of each cup; this can either be done by the teacher or students with some tacks or pins.

II. Each cup should then be filled 3/4's of the way with the student's assigned soil type.

III. Each student will use their pencil to make a hole in the middle of their soil about 1 inch deep, and place 2 beans in the hole. They should fill in the hole to keep the seed covered.

IV. Place the bean cups on a lab tray to catch any water that trickles down, and for better storage. For the first day of watering, each student should add enough water to moisten the soil completely through. The black Sunset cinder soil will need the least, and the Wupatki Red Soil will need the most.

V. All of the cups should be placed in the same place in the classroom, near sunlight or under a UV plant light. Water should be added about every other day, or enough to make sure the soil is **DAMP**. You do not want to over water the beans, or let them dry out too much.

Step 5: **Data/Measurements**. Have students record their first day data in their Lab Data Journals. Each student should record how much water they used (in # of spoons or mL), if there is any growth, how much growth and if they see any leaves each day. Repeat this for as long as you run the experiment. Make sure to account for weekends on your Day #.

Step 6: The length of this lab is suggested to be a minimum of 3 weeks long, but is left to the discretion of the teacher and the school's available time. At the end of the lab, the class should come together to compile the data and evaluate what the data means. There are questions at the back of the Lab Data Journal to help with this.

Suggested extension: Have the students graph their results for each soil type and compare those graphs.

Step 7: Have the students reflect on how the three different soil types would have affected life at each monument.

Other Observations to Be Made:

Students may take notice how the water condenses on the sides of the cup each day, or how the roots grow. Other observations may include noting which soils take longer to absorb the water, and which soils have other organisms in them.

Assessment:

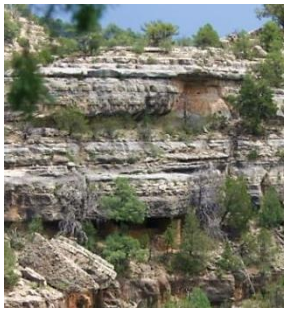
The assessment for this lab has room for adaptation and modification. This particular lesson involves a prediction and outcome analysis and reflection on results by the students. Students will use the questions at the back of their Lab Data Journals to reflect on what they observed and expected. Please see the attached Lab Data Journal in the appendix. Teachers for this grade range may also consider using the "Bean Lab Summary Sheet" in the appendix, or a modified set of questions.

Possible Results (Teacher Notes):

The beans should start sprouting between 5-8 days after planting. During a trial run of this experiment, the Wupatki soil grew the fastest, while the Walnut Canyon soil took longer. This could possibly be related to the amount of clay that exists in the Walnut Canyon soil. Once the plants were able to fully sprout with leaves above the soil, the growth rates increased. Initial growth may be measureable multiple times in the first few days when the sprouts are first breaking soil; it is up to the teacher to decide what time each day measurements should be made, and it is recommended that that time remain consistent.

Site Visit:

It is suggested that classes visit one of the 3 monuments and compare what they saw in the lab to what they can see at the monument itself. Students can compare the soil they saw in class to what is around them at the monument. They can predict what vegetation they could see before their visit, and then compare it to what they actually see. There are many resources available at the monument, which may be made available for your visit.



Wupatki National Monument has its own vegetable garden for visitors to see. Students could compare what they see to what they saw in the lab, and then talk to a Park Guide to understand how the park compensates for the growing conditions at the park today.

Walnut Canyon National Monument is a great place to see how water was transported and moved over hazardous terrain, by imagining people climbing ladders and canyon walls while carrying large ceramic jars. You could have the students draw what they think life would have been like here, or make a storyboard.

Sunset Crater Volcano National Monument is a great place to see how natural disasters caused people to move and adapt. Check out a lava flow and see which plants have come back and taken root out of the lava flows.

You may also contact the monument directly to see if there is any availability for a Ranger lead program that could focus on plants and farming at that monument.

Possible Extensions:

~ Soil nutrient rehabilitation. Students could use Miracle Grow to see how that affects the growth rates.
~ Vary the water amounts used to grow the beans.
~ Start a class garden.
~ Maintain the beans, and see how long they last.
~ Maintain the beans, and learn how to cook with them.

The Author:

As part of the Teacher-Ranger-Teacher Program, through the National Park Service, and the America's Best Idea Grant, Amanda Stalvey was hired for the summer of 2013 to design and develop lesson plans that could bring the National Monuments around Flagstaff into the classroom, and spark interest to bring both classes and the community to the parks. Amanda is a Flagstaff native who teaches science at Coconino High School and has a background in Natural Resource Management. The photographs depicted in this lesson are also taken and provided by Amanda Stalvey.

Acknowledgements:

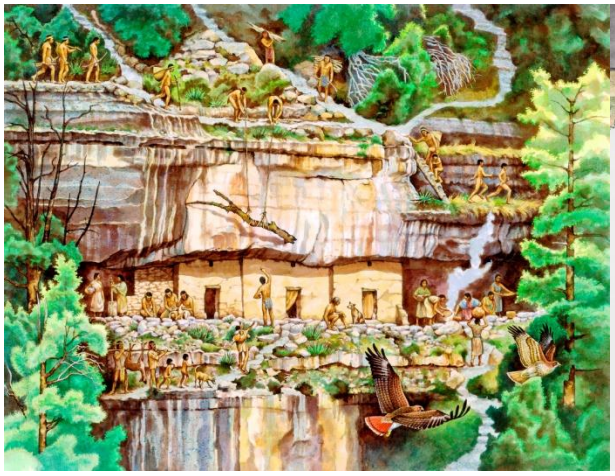
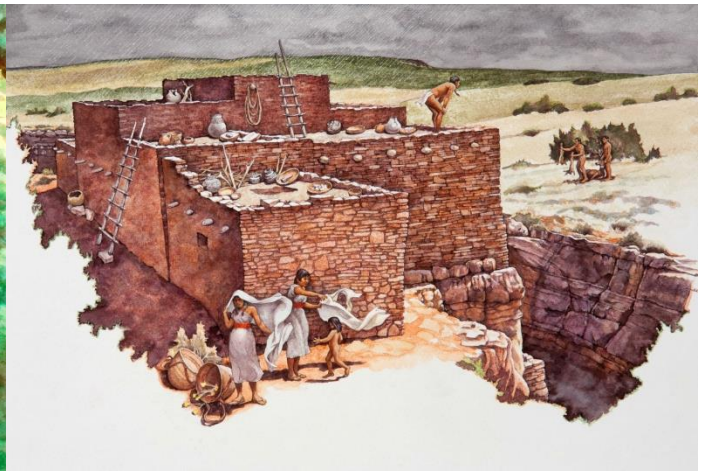
We would like to acknowledge and thank the Coconino National Forest Service for their help in collecting and permission to use soil from Forest Service land for this project. We would like to recognize Brian Crosby for his previous work and compilation of background information, and Western National Parks Association for the use of their publications to develop this lesson.

Lastly, we would like to thank Holly Richards, Lisa Baldwin, Sara Feldt, Cassandra Roberts[1] and the numerous other specialists at the National Park Service for their help and information throughout the development of this lesson plan.

[1] Created in association with Willow Bend Environmental Education Center, Flagstaff, Arizona, and the National Park Foundation America's Best Idea Grant.

Appendixes:

Below you will find the background information handouts, Data Lab Journal, and optional additional question worksheet.

Ancestral Puebloans Background Information

The name Ancestral Puebloans is a name used to identify many historic cultures that resided in the southwest, and to whom many modern American Indian tribes have descended from. Looking specifically at the people who lived around or near the Flagstaff Area National Monuments, archeologists will find small variations in tools used, and ways of life depending on the location and time period they were used. However, it is understood that the people who lived here migrated and traded with each other and many have cultural ties to each other.

The earliest people to pass through these areas left few traces. Their only remains are hand-size figurines cached in a cave more than 3,000 years ago, surprisingly old for artifacts made from highly perishable willow branches. Some investigators think these split-twig figurines represent bighorn sheep and may have been part of an early hunting ritual. Similar figurines have been found in caves at the Grand Canyon farther north.

By A.D. 600, early farmers had settled east of the San Francisco Peaks. They lived in small pithouse villages and farmed the open parks in the forest. Like many Pueblo communities of the American Southwest, the Ancestral Puebloans employed dry-farming techniques to harvest corn, squash, and beans in volcanic terrain. Otherwise known as the "three sisters," these crops were drought-resistant and ideal for dry farming, since corn can tolerate the sun and shade its lower growing sister crops, squash and beans, which do not require direct sunlight in order to thrive.

To irrigate these crops in the semi-arid climate, the Ancestral Puebloans built terraces and small rock check dams that allowed them to conserve rainwater. They also collected water from nearby sources of streams and creeks, and collected rain water. The Ancestral Puebloans did not rely on one strategy for collecting and gathering food alone; instead they preferred to use a combination of hunting, gathering, and farming. Major game animals hunted by the Ancestral Puebloans include pronghorn antelope, jackrabbits, cottontails, mule deer, and bighorn sheep. The Ancestral Puebloans also collected wild plant foods including piñon nuts, grass seeds, prickly pear and cholla fruit, agave hearts, and the berries and leaves of many shrubs.

A major portion of the Ancestral Puebloans diet did come from the products of their agricultural practices. Some practices included irrigation, floodwater farming at the mouths of arroyos, and dry farming. The Ancestral Puebloans had to make use of multiple strategies to maximize the use of their marginal environment and provide themselves with enough food to survive.

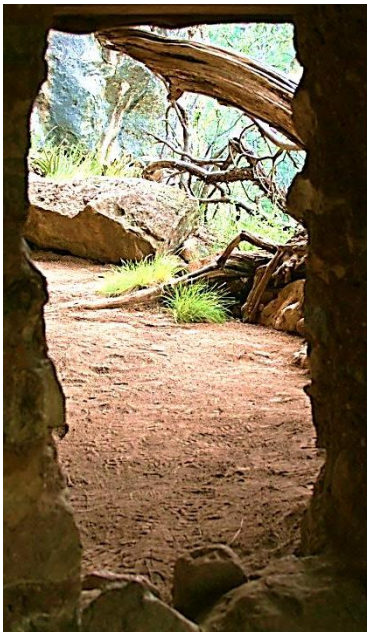
---

* Information contained here is a compilation of information taken from Western National Parks Association Publications, the National Park Service webpages associated with each park, and information written and compiled by Brian Crosby during an internship with the NPS. For more information please visit www.nps.gov or a national monument.

Walnut Canyon

Walnut Canyon resides at the southeastern edge of the San Francisco volcanic field, a geologic formation that contains over 400 cinder cone volcanoes, lava flows, and other volcanic formations. The San Francisco Peaks, the four summits of the extinct volcano just north of Flagstaff, is the most prominent feature of the San Francisco volcanic fields. The canyon itself was formed by the erosional processes from Walnut Creek, which flows northeast from Mormon Lake. Twenty miles long, 400 feet deep and ¼-mile wide, it was carved by Walnut Creek over a period of 60 million years. Within its winding walls are natural riches – an abundant mix of plants and animals drawn there by water and varied topography. It seems a timeless place.

The environment in the canyon can be divided into four unique ecological zones created by different moisture and temperature conditions that exist throughout the canyon. The north rim of the canyon mostly contains piñon pine and Utah juniper, the south facing slope features mutton grass and sagebrush, the canyon bottom contains box elder and Arizona black walnut, while the north facing slope is dominated by Douglas fir. The direction of the sun on the slopes of the canyon creates the different zones because of the different amounts of sun and moisture the different zones receive.



Walnut Canyon looked very different when it was inhabited over 700 years ago. The rim of the canyon contained cultivated croplands created by the residents to sustain them. The water flows through the canyon would have been unrestricted by dams, and would have washed the soft sediment and vegetation that builds up on the canyon floor today, to wash downstream.

Walls of buff sandstone form the canyon's inner gorge; the rock contours reveal their origins in the wind-scoured dunes of an ancient desert. The limestone ledges of the upper canyon contain delicate marine fossils, remnants of a later sea. Much later, the people of this canyon built their sturdy homes in shallow alcoves along these ledges.

---

* Information contained here is a compilation of information taken from Western National Parks Association Publications, the National Park Service webpages associated with each park, and information written and compiled by Brian Crosby during an internship with the NPS. For more information please visit www.nps.gov or a national monument.

Wupatki

Heat waves distort the horizon. Constant winds sap moisture from every pore. Tantalizing thunderstorms build but cheat the land of rain. The rock walls of an 800-year-old pueblo frame a landscape offering little obvious source of food, water, or comfort. On a summer day, the high desert of Wupatki seems much the same today as when, amid the rumblings of Sunset Crater Volcano, Ancestral Puebloan people settled here. In this region of dramatic geologic landforms, climatic extremes, scarce water, and diverse plant and animal species, they created self-sustaining lives. Wupatki National Monument was established to preserve the archeological sites from which we can learn about past and present cultures.

Archeologists, geologists, meteorologists, and other scientists classify the environment around Wupatki as "arid" because it receives less than 8 inches of precipitation a year. Because of the arid environment water was a precious resource, especially during the spring and fall dry seasons. The Ancestral Puebloan people modified their landscape just as people modify their landscapes today. In fact, the environment around Wupatki today was partially shaped by these ancient people 800 years ago. The people who inhabited Wupatki grew most of what they ate, and in turn they changed the composition of the soil. Gathering wood for fires and construction has changed the woodlands for miles around.

To conserve the little rainwater that fell, the Ancestral Puebloans built terraces and small rock check dams. Following the Sunset Crater volcanic eruption, farming in Flagstaff became less of a challenge for the Ancestral Puebloans people, because they discovered that the small layers of cinder and ash blanketing the northeastern lands helped keep the soil moist. As a result, a new agricultural community spread in the northeastern part of the region, where the people built larger multi-level pueblos--instead of smaller scattered pithouses as had been their tradition before the volcanic eruption.

* Information contained here is a compilation of information taken from Western National Parks Association Publications, the National Park Service webpages associated with each park, and information written and compiled by Brian Crosby during an internship with the NPS. For more information please visit www.nps.gov or a national monument.

Sunset Crater Volcano

Over 900 years ago, the eruption of Sunset Crater Volcano in Arizona forced the people living in the region of present day Flagstaff to evacuate their homes and the lands they had cultivated for 400 years. There must have been enough warning for the inhabitants to move out of harm's way; no evidence has been found that people died as a direct result of the eruption. However, pithouses for miles around were burned and filled with cinders, and others undoubtedly remain buried beneath layers of lava. The eruption not only destroyed homes, but it also changed the land, making it difficult for the Sunset Crater community to grow crops. People relocated, some to nearby Walnut Canyon and others to Wupatki, where they found that thinner layers of ash and cinders actually benefited crops by holding moisture in the soil. Agriculture and trade flourished for about 100 years before people once again moved on. Their descendants, including the Hopi and Zuni, still live nearby; memories of the eruption live on in their stories and traditions.

Before this volcano erupted, there was fertile soil here. The fields that were here are buried now beneath hundreds of feet of cinders, and the landscape has changed forever. New soil is forming, but it's a slow and precarious process. Weathered particles and bits of organic matter must accumulate between the cinders in order for most plant species to germinate, survive, and reproduce successfully.

In the early stages of soil formation, this process is easily disrupted. Any disturbance can dislodge the particles and cause them to sift deeper into the cinders, where they may be out of reach for use by plants; plants already established may also be dislodged.

---

* Information contained here is a compilation of information taken from Western National Parks Association Publications, the National Park Service webpages associated with each park, and information written and compiled by Brian Crosby during an internship with the NPS. For more information please visit www.nps.gov or a national monument.

Reflection:

Look back at your hypothesis and compare your actual results. How were they the same?

How were your results and hypothesis different?

What does it mean to you?

Data Lab Journal

Name: _____

Soil Type: _____

Soil Color: _____

Hypothesis of Results:

Why do you expect these results?

Data Sheets:

Day	Water? Amount	Growth?	# of Leaves	Height of Plant
1				
Illustrations or Observations:				

Day	Water? Amount	Growth?	# of Leaves	Height of Plant
2				
Illustrations or Observations:				

Day	Water? Amount	Growth?	# of Leaves	Height of Plant
Illustrations or Observations:				

Day	Water? Amount	Growth?	# of Leaves	Height of Plant
Illustrations or Observations:				

Day	Water? Amount	Growth?	# of Leaves	Height of Plant
Illustrations or Observations:				

Day	Water? Amount	Growth?	# of Leaves	Height of Plant
Illustrations or Observations:				

Day	Water? Amount	Growth?	# of Leaves	Height of Plant
Illustrations or Observations:				

Day	Water? Amount	Growth?	# of Leaves	Height of Plant
Illustrations or Observations:				

Day	Water? Amount	Growth?	# of Leaves	Height of Plant
Illustrations or Observations:				

Day	Water? Amount	Growth?	# of Leaves	Height of Plant
Illustrations or Observations:				

Day	Water? Amount	Growth?	# of Leaves	Height of Plant
Illustrations or Observations:				

Bean Lab
Summary Sheet:

Name: _____

Soil Type: _____

1. Look back at your hypothesis and compare your actual results. Was your hypothesis correct or close? Why or why not?

2. Take a look at your classmates' bean cups and their results. How did your results compare?

3. Which soil type produced the fastest growing or tallest bean plants?

4. Why do you think your answer to #3 did so well? What makes that soil work so well?

5. Which soil type produced the least number of beans or the smallest?

6. Why do you think your answer to #5 did so poorly? What makes that soil harder to grow in?

7. How do you think the soil from these three different monuments might have affected the people who lived and farmed here?

8. Arizona is a dry and arid desert that does not get much rainfall. How do you think the Ancestral Puebloan people might have compensated for the lack of water?

9. Think back to the background information about the Ancestral Puebloan people and the three monuments. Is there evidence that people actually farmed at Sunset Crater AFTER the volcano erupted?

10. What do the bean lab results tell you about the Sunset Crater Volcano growing ability?

11. If you could do this lab again, what would you have done differently? OR How could you change this lab to learn something new?